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Benefit-Cost Assessment Handbook for Water Programs Volume I

Draft

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Benefit-Cost Assessment Handbook for Walter Programs Volume I

Prepared for

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PREFACE

As one component of the decision process, water program offices at the Federal, State, and local levels along with advisory citizen groups have perceived the need to consider the beneficial and detrimental effects of policies that affect water quality. In response, the U.S. Environmental Protection Agency's Office of Policy Analysis sponsored the development of this Benefit-Cost Assessment Handbook for Water Programs. This experimental handbook will not short-circuit any Federal, or local water quality laws. Rather, it provides suggestions about how to evaluate the economic aspects of a proposed policy as a regular part of the decision process. These evaluations can identify water quality policies that have highest priority, so that society's resources can be directed to the areas that will have the greatest benefits. They also can serve as one of several analyses that support the decision process for any specific water quality policy. Such an approach can help assure the attainment of our Nation's water quality goals with a minimum expenditure of resources.

The Benefit-Cost Assessment Handbook for Water Programs is a primer. It assumes only a limited familiarity with economics. Throughout the handbook, case studies help to clarify points. Data needs, key assumptions, and other relevant points are covered for different ways of determining the relationship between desirable and undesirable effects of a program decision.

Since water program offices have begun to move toward the use of benefit-cost concepts, the scope of the handbook is broad enough to explain how to conduct benefit-cost assessments in diverse applications. The costs and health benefits of drinking water policies are covered elsewhere, so this handbook concentrates on the benefits and costs for other water programs. Although most of the examples in this volume are for hypothetical water quality standards decisions, the tools can be applied to a broad spectrum of water quality decisions, and even to environmental issues in general.

If there is sufficient interest in this experimental approach, a second volume may be developed to provide more in-depth discussion of the benefit-cost assessment for use by practitioners. It also may be desirable to tailor a similar document for specific water programs. The Office of Policy Analysis welcomes comments and suggestions, which may be directed to:

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ACKNOWLEDGMENTS

Why are the acknowledgments always the last section to be written in any report? This question, which often occurs on the way to work toward the end of a project, is likely one without a definite answer. We could surmise that it comes from an unwillingness to let go at the end of any project (not likely) or simply that we have saved the best for last.

We are indebted to many people who have given of their time to assist us in writing this handbook. Yet there is one person whose commitment to the project stands out. That person is our project officer at the Environmental Protection Agency (EPA), Dr. Ann Fisher. The simple truth is that without Ann Fisher this handbook would not have been written. With the many hours she has given to the project she is more author than anything else. Since she would never have allowed this acknowledgment to appear in the report had she read it, perhaps this is the reason for leaving it until last.

As this handbook has evolved, it has drawn from many sources. Chapter 4 pertaining to the costs of regulatory actions draws heavily on an earlier chapter prepared by Metasystems, Inc., and particularly Tze-Wen Chi and Peter Morgan. Indeed, most of the examples are taken from this earlier draft. Assistance on the cost chapter came from the Office of Analysis and Evaluation under Louis Dupuis. John Kukulka and Joe Yance from the staff suggested many helpful revisions in support of the project.

Office of Policy Analysis staff members provided valuable detailed critiques of early drafts. Reed Johnson, Bob Raucher, Peter Caulkins, and Skip Luken gave good counsel. Joan O'Callaghan's valuable editorial suggestions on an early draft have been incorporated into this draft.

The EPA staff in the water program area have also played an important role in this project. Patrick Tobin, Dave Sabock, and Marjorie Pitts of the Office of Water Regulations and Standards, Myron Temins and Charles Moar of the Office of Water Programs Operations (OWPO), and Jerry Manorola, formerly of OWPO, gave extensive comments.

In addition, helpful comments were received from Dan Huppert, MNFS Southwest Fisheries Service; Robin Gottfried, University of the South; John Luensman, Department of Planning and Development, Chautauqua County, New York; John Loomis, U.S. Forest Service; and Mike Piette, University of Hartford.

Finally, the RTI staff has been most supportive. Tayler Bingham brought his experienced view of environmental regulations to bear on all of the drafts of this handbook. Tayler's insightful comments are valued highly. Hall Ashmore's editorial efforts mark every page of this handbook. Hall's economy with words and his ability to make an author's prose bear fruit are assets for any handbook or report. Finally, Jan Shirley and the Institute's Word Processing Specialists have done yet another outstanding job of producing a pleasing report. Jan's devotion to quality and her ability to know when to coax or cajole a reluctant writer are most appreciated.

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CHAPTER 1

BENEFIT-COST ASSESSMENT: A COMMON SENSE APPROACH TO DECISIONS

1.1 INTRODUCTION

Should a State change the designation of impaired uses for a river? Will a sewer overflow project provide benefits in excess of costs? Is advanced waste treatment necessary to attain a river's designated uses? Are treatment plants more desirable on some rivers than on others?

This handbook--a primer on benefit-cost assessment--shows how economic principles can help decisionmakers make these difficult choices. Its primary intent is to demonstrate the common sense inherent in benefit-cost assessments of alternative choices. In addition, this handbook shows how to add an economic dimension to scientific and technical analyses in considering the full range of impacts from a proposed water quality action.

Since they focus on the alternatives available to society, economic principles are especially relevant to water quality program problems. Specifically, the economic viewpoint recognizes that the scarcity of society's resources forces choices among alternatives. However, choosing among alternatives creates tradeoffs--i.e., one thing must be given up to attain another. Thus, water quality decisions produce both desired and undesired effects for society. Benefit-cost assessment simply uses economic principles to help the decisionmaker make these choices.

Water quality programs implement regulatory mandates or provide assistance either to those adversely affected by the regulations or for specific projects. Principles covered in this handbook could be applied to:

- Effluent guidelines issues that require limits on specific industrial discharges.
- Water quality standards issues where States designate uses for water bodies and develop criteria to achieve the uses.
- Advanced treatment issues where the Federal Government provides financial assistance to construct municipal treatment plants that require advanced technologies.
- Combined-sewer overflow issues where Federal assistance is provided to deal with municipal runoffs that create pollution problems.

This chapter discusses the basic principles in a benefit-cost assessment. Specifically, Section 1.2 provides an overview of regulation, using linkages between regulatory actions, effects, and changes in behavior. To highlight the basic principles, Section 1.3 describes benefits from an economic perspective, and Section 1.4 details a similar discussion for costs. The basic concepts of benefit-cost assessment are described in Section 1.5, along with a step-by-step view of an assessment. Section 1.6 gives some groundrules for performing an assessment and Section 1.7 summarizes the key points in the chapter. Finally, Section 1.8 provides a guide to the remainder of Volume I of the handbook.

1.2 REGULATION: AN OVERVIEW

Understanding how benefit-cost assessments can be used is easier with some knowledge of how a regulation affects economic activities. The key to this understanding is the linkage (shown in Figure 1-1) between (1) a change in a regulation (an action), (2) its technical effects, and (3) the behavioral responses to it.

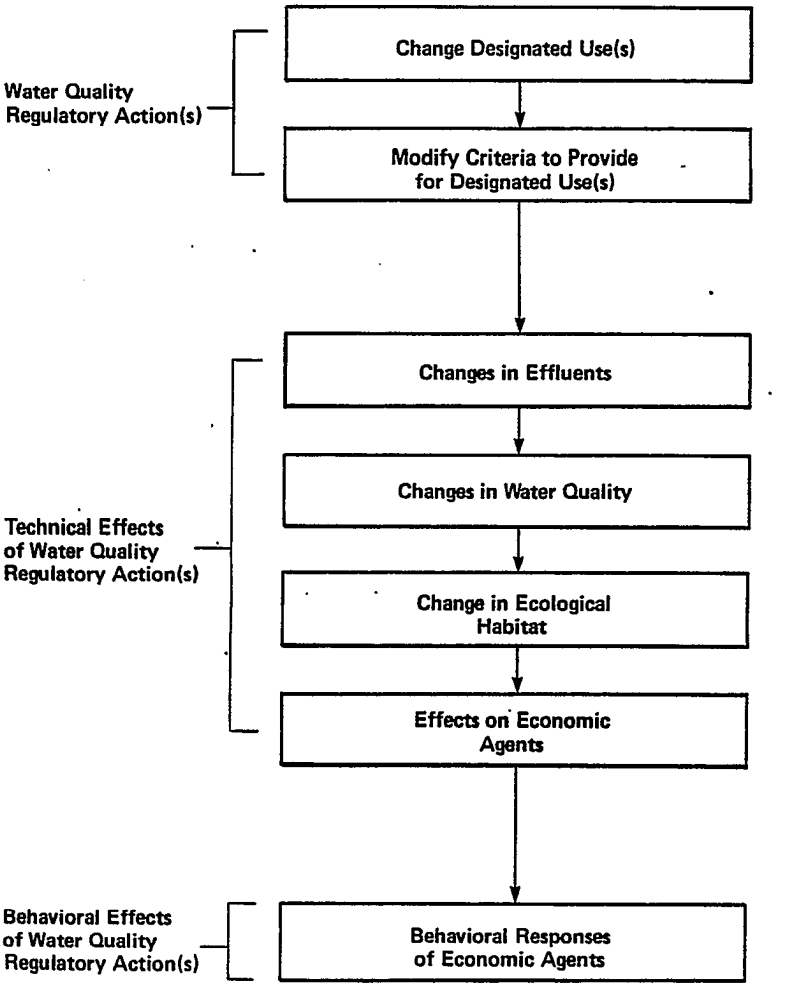

Figure 1-1. Effects and responses to water quality regulatory actions.

One example of an action represented by the first two blocks in Figure 1-1 is a change in the uses designated for a water body and the associated modifications of technical water quality criteria to accommodate these uses. The action changes effluent levels and the resulting water quality and ecological habitat--all of which affect households and businesses, the primary economic agents. A change in effluent levels simply means more or fewer pollutants will be discharged into the water body, thus altering overall water quality. The changes in water quality alter the diversity of microorganisms, fish, or flora and fauna and can noticeably change the local ecological habitat. The magnitude of the technical effects depends on specific water body characteristics, the nature of the pollutant being controlled, and the extent of control. For example, river depth, flowrate, and riverbed geology will influence the technical effects of changing the designated uses of a river to include a warmwater fishery.

Not all water quality programs are regulatory programs. For example, the combined sewer overflow (CSO) program aims at directly enhancing water quality by reducing the surge of pollutants following a severe storm. Even in these programs, a determination of the linkages between the project and its technical effects is essential.

Equally important to benefit-cost assessment is how businesses and households are affected by the action. For example, if improved water quality will support a warmwater fishery in a watercourse, more gamefish will likely inhabit the river, thus enabling fishermen to catch more fish--the technical effect on the household. However, to achieve the level of dissolved oxygen necessary to support gamefish, regulation might be required so that firms clean up their discharges into the river. From society's viewpoint, therefore, actions have both beneficial and detrimental effects. Maximizing the public good requires consideration of both types of effects.

Determining how beneficial and detrimental effects balance out requires consideration of the final linkage--how primary economic agents change their behavior in response to technical effects. For example, if the technical effects of a water regulation (e.g., an increase in gamefish populations) allow fishermen currently using a watercourse to use it more, new users may be attracted to the site. In economic terms, this situation is described as increased demand for a site's recreation services. The amount of the demand increase will be determined both by site attributes (features) and by the site users. Important site attributes include the proximity of substitute fishing streams, the number of access points, and the quality of local natural features, such as the surrounding countryside. The incomes of the fishermen, the price of fishing equipment, and how badly the users and potential users want to fish--their preferences for fishing--will also affect the ultimate behavioral response to increased gamefish populations.

However, just as households (or fishermen, as in the example) respond to the technical effects of regulatory actions, firms also respond. Specifically, they may decide to close down operations, alter waste treatment processes, or alter product mixes to meet the technical standard required by the decision. Clearly, each of these behavioral responses has different conse-

quences, but the magnitude of the regulation's technical effects is determined by the range of feasible responses and the market conditions for the goods produced by the affected businesses. Thus, firms facing more favorable market conditions find a wider range of choices open to them, and those facing strong pressures from competing firms are more limited.

The actual regulatory process is considerably more complex and less certain than indicated above. For example, businesses using water in their production process could be adversely affected by the regulation if higher dissolved oxygen levels corrode their water pipes, resulting in higher operating costs. Similarly, individuals who are not users of the site may be affected if they view general increased ecological diversity as a beneficial effect. In the end, therefore, practitioners will have to determine which effects are relevant for inclusion in the benefit-cost assessment.

More importantly, the linkages discussed in this section do not attach values to the positive and negative effects. Rather, they merely suggest a way of viewing the regulatory process to help determine what the effects are. In some cases, however, the decision process is eased if effects are converted to values. Unfortunately, the attachment of values to the effects is a troublesome process for many potential users of benefit-cost assessment.

1.3 BENEFITS: AN ECONOMIC VIEW

The economic approach to defining and measuring regulatory benefits is unfamiliar to many noneconomists. Quite simply, however, economics approaches benefits from society's perspective, assigning values based on individuals' willingness to pay for particular regulatory effects.* In essence, economics implicitly assumes individuals are best suited to value the effects of water quality programs.

Once both the beneficial and detrimental effects of a proposed action have been identified, the practitioner may need to weigh their relative importance before a final decision is made. Of course, the economic valuing process described above can help determine relative importance--e.g., area fishermen's willingness to pay for an action to increase gamefish populations vs. the costs incurred by a local industrial plant whose discharges the action will require be cleaned up--but it has limits. Indeed, no approach--economic or otherwise--is a substitute for the judgment that decisionmakers must exercise to make choices among alternatives representing various types and degrees of well-being to a variety of population subgroups (fishermen, plant owners, etc.). Benefit-cost assessment is a framework for identifying and organizing information to ease the decisionmaking process, not a decision rule.

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*It should be recognized, however, that, added up over all persons, individual willingness to pay is influenced by the income, or wealth, available to each person.

One frequently asked question is, "Why do people have to 'pay' for the beneficial effects of water quality programs?" The answer is that they do not; alternatively, they could accept payment to forgo the effects. In effect, the two measures--willingness to pay and willingness to accept--are equally good, but different, measures. While the "accept" measure implicitly assumes the individual "owns" the rights to the beneficial change, the "pay" measure assumes the opposite. Volume II of the handbook will discuss how benefits based on these two different measures can be related. The important distinction is the equity question--i.e., whether individuals own rights to the program benefits.

Although willingness to accept is an equally good measure, willingness to pay is normally used to discuss regulatory benefits because it can be revealed in markets, when they exist, through purchases of goods or services affected by the program. Then, benefits can be measured empirically. Although these markets clearly do not exist for the effects of water quality improvements, willingness to pay is still a useful way of valuing benefits. An assessment may describe benefits only in qualitative terms, but the description can be written from the perspective of willingness to pay. The benefits measurement approaches discussed in Chapter 3 are ways that economists have approached the benefits problem when markets do not exist. None of these approaches gives precise estimates of willingness to pay. Each is a blunt tool, capable only of giving rough estimates, which are sufficient in most cases.

1.4 COSTS: AN ECONOMIC VIEW

Opportunity cost measures the cost of any resource--e.g., labor, machinery, environmental resources--in terms of its next best alternative use. That is, the value of forgone alternative uses of any resource provides the basis for estimating the cost of any specific use. As a result, opportunity cost considers tradeoffs--i.e., how much must be given up of one thing to have more of another.

For example, assume a proposed project would improve a lake's water quality to permit recreational fishing, boating, and swimming. The lake cannot now support any of these activities, but it would if quality were improved by constructing a waste treatment plant along a river that feeds the lake. In this example, the opportunity costs of the action would be the forgone opportunities of all the resources used in improving water quality. In the absence of market imperfections, the opportunity cost of construction inputs--equipment, materials, labor, land, etc.--would be valued by their market prices. In addition, if the action precludes use of the river or the lake for other activities (such as industrial or agricultural uses), the values of these forgone alternatives would also be part of the opportunity costs.

Many practitioners consider cost estimation an easier task than benefit estimation. Perhaps a more accurate view is that many find it less objectionable to value the labor, materials, and equipment used as a result of an action. However, difficulties can arise when the full social costs of the investment alternatives are considered, or when effects on rates of technological change are included. Cost estimation is likely to involve as many judgments

as benefit estimation and is subject to the same general cautions. Indeed, caution is advised in making too great a case for precision in the measurement of economic well-being when less precision than desired exists in the linkage between the regulatory action and its effect on economic activities. The problems in establishing linkages do not imply these technical issues should be ignored, only that they be considered in their proper perspective--as a part of the problem of evaluating the benefits and costs associated with a change in water quality.

1.5 BENEFIT-COST ASSESSMENT: WHAT IS IT?

Benefit-cost assessment is a way of organizing information--a method for identifying all the favorable and unfavorable outcomes of a proposed action. Where necessary for complex decisions, many of these outcomes can be converted into a common set of units (usually dollars) to permit consistent comparisions of benefits and costs. Monetization may be impossible for outcomes which defy measurement. Even in these cases, the benefit-cost assessment framework can organize information associated with an action. In short, benefit-cost assessment is a practical method for including basic economic principles in the decision process.

Although benefit-cost assessment is a guide to decisionmakers, it does not provide the final answer to a public policy decision. Other factors such as the public's view of appropriate uses for a particular water body or the fairness of cost impacts on particular groups are important considerations. What a benefit-cost assessment <u>does</u> do is provide an organizing framework for information the public and rulemaking body can use in making more informed decisions.

It is important to recognize that value judgments are a part of all decisions. Benefit-cost assessments supplement scientific and technical information with economic information that may help decisionmakers make these judgments. Very simply, a well-structured benefit-cost assessment can reduce the complexity of what needs to be considered, making the decision process more manageable.

<u>Is Benefit-Cost Assessment Different from Cost-Benefit Analysis?</u>

One of the first things that comes to mind for potential practitioners of benefit-cost assessment is the past misuse of cost-benefit analysis. These misuses emphasized the search for a ratio--the one "number"--that would rationalize or justify a project. In many instances, the misuses involved an attempt to include benefits that were, at best, marginally related to a project. This is not the case for the benefit-cost assessment suggested in this handbook. Since benefit-cost assessment requires a consistent, systematic treatment of benefits and costs, an outside observer can easily discover when a practitioner tries to stretch the approach beyond the limits dictated by common sense. When the assessment process is carefully conducted, common sense will provide a reasonable guide through most of the decisions. Anything not sensible should be scrutinized. Critics who maintain that benefit-cost assessment can be used to justify anything overlook the fact that any approach can be abused.

Since it can compare benefits and costs in qualitative terms, in qualitative terms with some quantification, in quantitative terms, or in monetized terms, benefit-cost assessment is a more flexible approach than conventional cost-benefit analysis. The key, of course, is the nature of the decision. A qualitative assessment will reveal whether the potential benefits and costs at stake in a water quality decision are clearcut. No further economic assessment will be needed, yet the decisionmaker will have a logical, consistent basis for economic considerations. If the situation is more complicated, or if the potential benefits and costs at stake are considerably larger, a more detailed benefit-cost assessment can make the decision more manageable.

Many ways exist to tailor a benefit-cost assessment to fit the needs of the issue at hand. For example, monetization can play a critical role in more complicated benefit-cost assessment decisions. Specifically, by blending monetization with qualitative judgment, benefit-cost assessment can determine whether the benefits bear a reasonable relationship to the costs involved and whether there will be significant impacts on certain parts of the population or the economy.

A misconception that arises with benefit-cost assessment involves recent techniques-- such as survey techniques--developed to deal with previously unmeasurable or nonmonetizable benefits, such as enhanced ecological diversity or amenities. These survey techniques are not opinion polls; they rely on carefully designed questionnaires to measure an individual's willingness to pay for these benefits. One fact has been clearly shown by all the survey studies: such previously nonquantifiable benefits are indeed a substantial component of the total environmental benefits picture. That is, the studies have shown these benefits to be large, and an assessment that overlooks them may indeed understate the full benefits. While most water quality decisions will not require a survey to determine these previously nonquantifiable benefits, some benefit-cost assessments may adapt the results of recent surveys for specific sites (e.g., see Chapter 6, Section 6.3). A few instances may occur in which, because the potential costs are so large, practitioners may want to use simple surveys to get at least a ball park estimate of such potential benefits.

Benefit-Cost Assessment: A Step-by-Step View

Each of us makes decisions every day, judging whether the anticipated consequences of an action will be "worth" the "costs." Of course, the meanings of "worth" and "costs" vary from one person to the next because different people evaluate the same action differently. Whatever the outcome, however, the logic underlying the decision process is the same. Based on this decision logic, benefit-cost assessment is a method for defining "worth" and "costs," offering a logical framework for structuring information for decisions in the public sector.

Although performing a benefit-cost assessment is not a mechanical task with each step completely known in advance, it is possible to outline the general steps that are useful in assembling a complete assessment. These steps

flesh out the linkages between a policy decision and the behavioral changes, highlighted earlier in Figure 1-1. For instance, an assessment can portray the individuals and firms that will be directly affected by a regulatory action, how they will be affected, and how they will change their behavior in response to the regulation.

The logic of a benefit-cost assessment is straightforward, as shown in the following steps:

- Define the action
- Determine an appropriate approach based on resources or complexity of the action
- Identify and estimate the incremental benefits of the action
- Identify and estimate the incremental costs of the action
- Compare the benefits and costs of the action
- Assess the plausibility of the results
- Highlight the distribution of benefits and costs and financial impacts of the action
- Integrate the assessment into other aspects of the decision-making process.

For example, Figure 1-2 illustrates these steps for a water quality standards action, such as a State's changing the uses designated for a river segment. Steps in the upper portion of Figure 1-1 assemble and organize the available data for the change in designated uses. The optional analyses of the technical aspects of a water quality standards decision--analyses for use attainability, site-specific criteria, and wasteload allocation--can be valuable sources of data on the technical linkages between an action and its effects. By sorting the data according to whether the action's effects result in a benefit or a cost to society, the State can compare, roughly, the benefits with the costs.

The level of difficulty in the benefit-cost assessment process is dictated by the complexity of the effects and responses to the program actions. For example, when benefits and costs of an action are clearcut and have values that are comparatively small, a simple qualitative assessment is in order. In these cases, the assessment process merely describes the distribution of benefits and costs--i.e., who in society receives the benefits and who bears the costs--presents the results, and organizes them for the water quality decision. However, if a qualitative assessment reveals that potential benefits and costs are substantial or not clearcut, a more detailed and comprehensive assessment is in order, as shown by the steps in Figure 1-3. In these cases, the practitioner must measure, value, and discount the benefits and costs and judge the sensitivity of the results. In most instances, staff resources and existing information can be combined for an assessment. In a few situations,

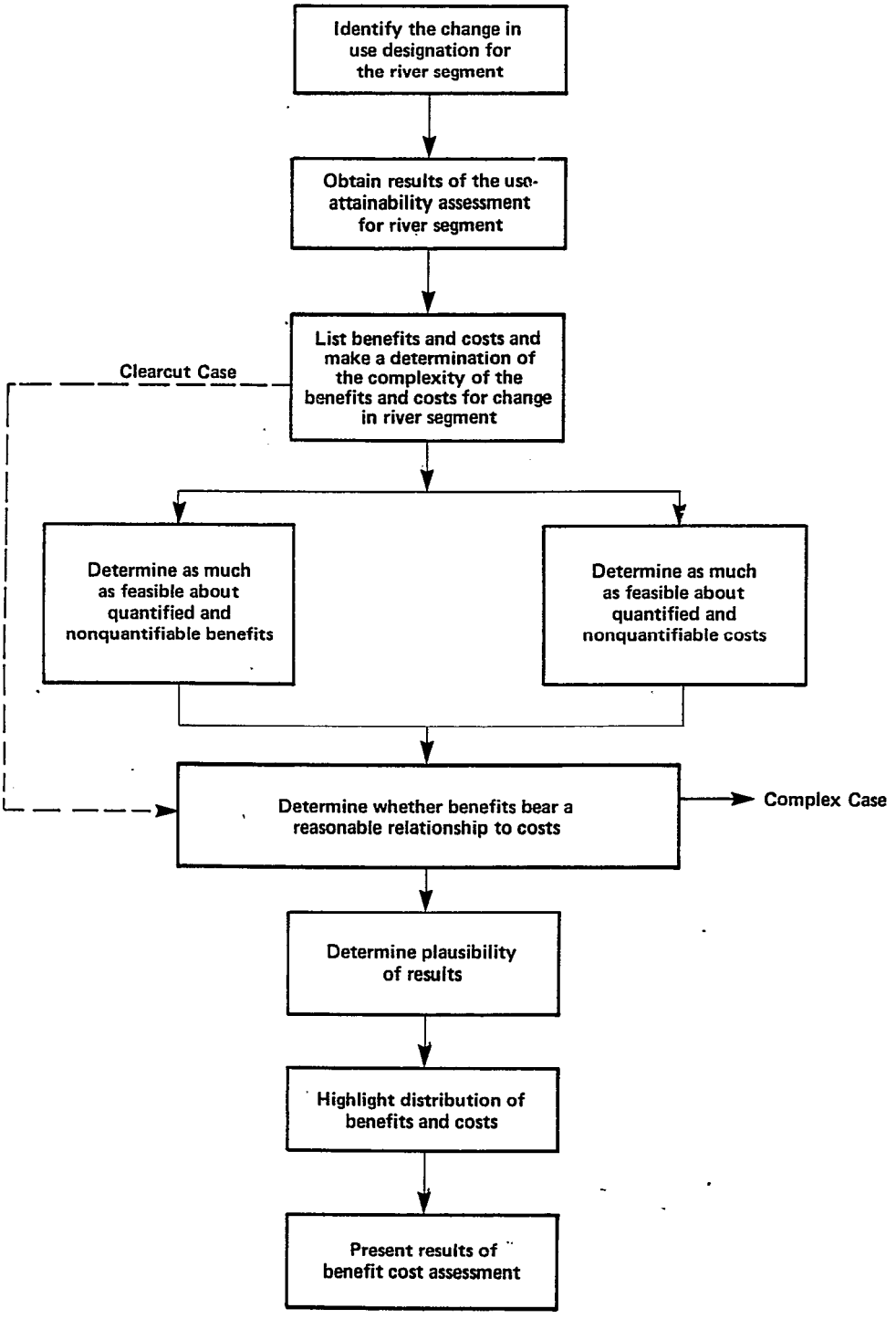

Figure 1-2. Key steps in a benefit-cost assessment.

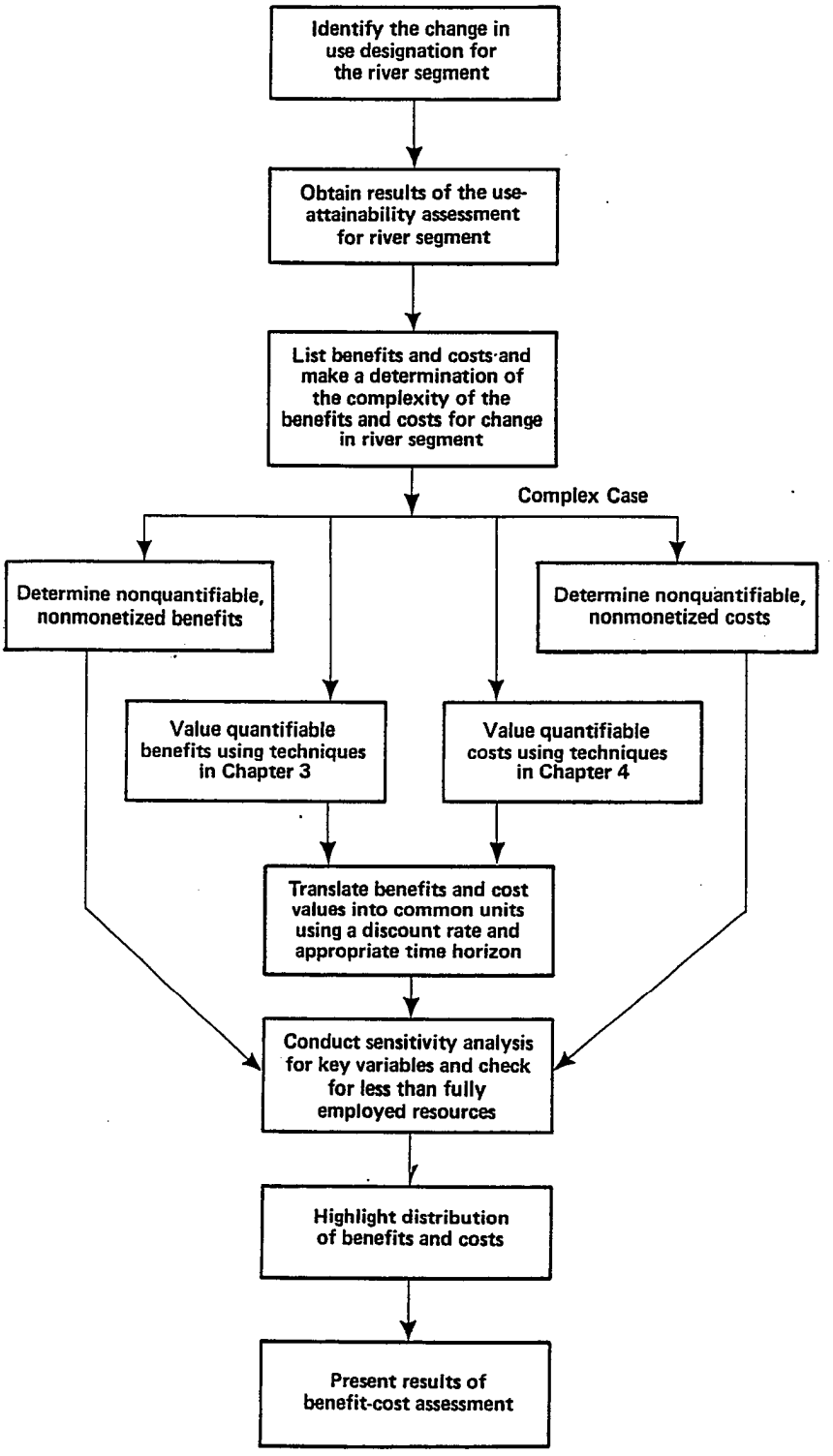

Figure 1-3. Key steps in a complex benefit-cost assessment.

outside assistance may be needed for a more detailed assessment; likely candidates include area universities and consulting firms. Regardless of outside assistance, following the flow chart can ensure good quality results.

Thus, the strength of benefit-cost assessment is its ability to organize material in a consistent manner and yet remain flexible enough to accommodate a wide range of cases. Nonetheless, the practitioner must recognize that each program action will introduce new complexities requiring judgments that can be made based only on an understanding of the strengths and weaknesses of the benefit-cost assessment process.

1.6 KEY CONSIDERATIONS IN AN ASSESSMENT

Four practical problems arise in implementing general benefit-cost principles: determining a baseline, determining the primary effects, avoiding double counting, and using expenditures to measure benefits.

The benefits and costs of any water quality action reflect both regulations already in place and specific features of the affected water bodies. This means the baseline must be identified before the benefits and costs of a new action can be determined. For example, technology-based requirements, and any variants of them, usually form the regulatory baseline for additional water quality decisions. In cases where the technology-based requirements have not been met, determining the baseline is difficult due to uncertainties in the predictions of the effects that the in-place regulations will produce. Effective enforcement is generally assumed for existing regulations. In an actual assessment, practitioners will have to make judgments about these baseline issues. If uncertainty exists in the determination of the baseline, this should be clearly stated and addressed later, when the plausibility of the overall assessment is considered.

The specific attributes of a site are also important in linking benefits with the effects of water quality decisions. For example, swimming benefits will not likely be significant for a river that is only a few feet deep in places and has considerable current, no complementary facilities (such as beaches or access points), or large amounts of barge traffic. However, swimming may be important when adjacent parks and facilities are present and pollution is the limiting factor, as is the case for certain river pools in the Mississippi River in the Minneapolis area [Larson, 1981]. Similarly, the costs of achieving a particular level of water quality will depend on site-specific water quality as it existed before the regulatory action took effect. The analyses of use-attainability site-specific criteria, and wasteload allocation, any one of which may be performed as an optional part of water quality standards decisions, can be a valuable source of technical information.

Another important distinction is between primary and secondary benefits and costs. Primary benefits and costs arise directly from the action, while secondary benefits and costs follow the impact of the primary ones. Only primary benefits and costs should be included in an assessment, because linkages are often too imprecise to make even a rough determination of secondary benefits and costs. For example, while increased recreation activities and

enhanced ecological diversity are among the primary benefits of a water quality improvement, the increased revenues to providers of recreation equipment, for example, are simply expenditures--secondary benefits-- not primary benefits. When these expenditures are included, the opportunities for double counting increase substantially. If increased receipts of recreation equipment suppliers are added to willingness to pay, then that part of users' willingness to pay is double counted. In effect, including secondary benefits in an assessment opens up the assessment to the same suspicions that plague some applications of traditional cost-benefit analysis.

The distinction between primary and secondary benefits is important in the solution of another problem that arises in a benefit-cost assessment: the use of an expenditure approach to measure benefits. The expenditure approach adds up an area's recreation-related expenditures. This reflects the costs of recreation, not an individual's willingness to pay for recreation. For example, the approach would include the costs of the fishing gear itself--amounts that are costs and not benefits. In addition, it does not count the difference between the maximum an individual would pay and the amount he actually pays--in technical terms the consumer surplus. In effect, the expenditure approach includes some costs on the benefits side of the ledger and excludes other benefits entirely.

Total recreation expenditures may be useful in identifying some of the effects on a community's economic activity (e.g., increased sales tax receipts or recreation-related employment). Even in this limited use, however, the use of total expenditures omits important flows of funds out of the community to pay for goods externally produced. Confusion on these points often results because it seems logical that expenditures should be benefits. However, expenditures are costs and benefits; they are not all benefits. Both double counting and miscounting occur when this approach is used.

1.7 SUMMARY

Benefit-cost assessment:

- Applies a formal dose of common sense to evaluating water quality regulations and programs.
- Provides a flexible approach for organizing the information needed to make water quality decisions.
- Enhances but does not supplant the value judgments of decisionmakers.
- Uses society as the basis for accounting benefits and costs.
- Focuses on individual willingness to pay and opportunity cost to measure benefits and costs, respectively.
- Concentrates on primary benefits and costs.

1.8 GUIDE TO HANDBOOK

This handbook is organized into six chapters. Chapter 1 is the introduction to benefit-cost assessment. Chapter 2 shows how to include intangibles and distribution effects in an assessment and considers the question of discounting benefits and costs. Chapter 3 describes specific methods for estimating the benefits of water quality programs, including techniques for developing the monetary components of benefits needed in complex cases. Chapter 4 gives the basics of estimating costs, focusing on the incremental costs of water quality regulations. Chapter 5 describes a sensitivity analysis as a guide to a plausible assessment and highlights methods of presenting the results of an assessment. Chapter 6 illustrates benefit-cost assessment practices with simple, moderately difficult, and complex causes to reflect different types of water quality decisions.

CHAPTER 2

ISSUES IN A BENEFIT-COST ASSESSMENT

2.1 INTRODUCTION

How can intangible benefits and costs be included in a benefit-cost assessment? What does it mean to discount benefits and costs? Are there rules of thumb for discounting? Does benefit-cost assessment ignore the distribution of benefits and costs?

In practice, the positive and negative effects of a program action occur at different points in time, affecting households and firms over a number of years. In many assessments the need or ability to monetize benefits and costs may be small, or limited resources may preclude monetizing. Clearly, a need exists for a logical approach to intangibles and for a convenient way to include them in an assessment.

For those assessments where benefits and costs are monetized, two main "adding up" issues arise: discounting and distribution. Discounting provides a consistent basis for adding benefits and costs over time. It is one of the most complex and controversial issues in an assessment. Similarly, simply adding benefits and costs over people or firms may hide important issues.

To explain how a benefit-cost assessment addresses these important issues, Section 2.2 discusses intang'ible benefits and costs and uses arrays, or tabular displays, to feature them in the assessment. Section 2.3 briefly describes how to measure impacts on firms and households, and Section 2.4 illustrates how the distribution of benefits and costs can be included in an assessment. Section 2.5 describes the discount rate, its role in a benefit-cost assessment and key issues in selecting a discount rate. Finally, Section 2.6 summarizes the chapter's major points.

2.2 INCLUDING INTANGIBLES IN A BENEFIT-COST ASSESSMENT

Introduction

The uses prescribed in the Clean Water Act for the water quality standards are likely to provide intangible benefits relating to enhanced species diversity and ecological habitats and improved aesthetics. By its incommensurability, this type of benefit presents problems for determining the net benefits of a use designated under the standards program--or for any water quality program. The types of benefits or costs that comprise the intangibles group change over time with improvements in valuation techniques. For example, the travel cost technique estimates willingness to pay for recreation benefits that initially were treated as intangibles. This section provides a

method for including intangibles in a benefit-cost assessment. Volume II will contain more details on intangible benefits.

A recommended method uses a system of tabular displays, or arrays, to present both tangible and intangible benefits. These arrays are tailored to fit the nature of the assessment being conducted. The first array simply lists and describes the benefits and costs. A second array presents monetized values only for those benefits and costs for which monetization is almost always accepted, with the remaining benefits and costs being listed, described, and quantified to the extent possible. These values are based on individuals' willingness to pay and opportunity cost as measured by the techniques presented in Chapters 3 and 4. The final array presents as many benefits and costs in monetized terms as possible, with the other benefits and costs being listed, described, and quantified.

Example

Suppose a State is considering adding the fish and wildlife use to a stream that is currently designated for agricultural and industrial uses. A system of arrays for a benefit-cost assessment of this change in use designation is illustrated in Tables 2-1, 2-2, and 2-3.

The first array (see Table 2-1) lists and describes all the benefits and costs in qualitative terms. In cases where issues are clearcut, this array would, by itself, provide information sufficient for making the decision. As issues become more complex, additional arrays are essential for information sufficient to make the decision

The second array for this example (see Table 2-2) presents monetary values for benefits and costs for only those categories that almost all practitioners agree can be monetized. This supplemental information in the second array clarifies the issues in the assessment by focusing attention on the nonmonetized values. This array shows that the low end on the range of monetized recreation benefits is exceeded by the high end on the range of the costs and that the action produces nonmonetized benefits. The decisionmaker would have to determine how the nonmonetized aesthetic benefits and ecological diversity influence the net result given the overlap in the range estimated for benefits and costs.

The system of arrays shows how a benefit-cost assessment can reduce the dimensions of a complex issue to focus the decisionmaker's attention on the most difficult aspects. The last array (see Table 2-3) shows the monetization of as many benefits and costs as possible. The range of monetized benefits is estimated to be $17 million to $37 million, with additional nonmonetized benefits attributable to the enhancement of the ecological diversity. The estimated costs of attaining the additional use designated range between $9 million and $14 million.

Several features of this example call for additional discussion. The estimated monetary values for aesthetic benefits move the benefit range to a level at which benefits exceed both the minimum and maximum estimates of the

Table 2-1. Benefits and Costs of Attaining Fish and Wildlife Use: Array 1

Description of Benefits

1. Provide an additional resource that can support swimming, fishing, and recreation near water in a metropolitan area with only limited substitutes available.

2. Improve the aesthetic value for users of the resources services, such as recreators or property owners near the stream.

3. Improve the aesthetic value for residents of the area based on possible use in future or just from knowing the stream is cleaner.

4. Enhance the ecological diversity of the stream area by providing an improved habitat for fish species and wildlife from surrounding areas. However, none of these species is unique or endangered.

Description of Costs

1. The residents of the city will require advanced treatment for their wastes.

2. Three industrial dischargers will have to modify their waste treatment operations.

Table 2-2. Benefits and Costs of Attaining Fish and Wildlife Use: Array 2

	Quantity	Monetary value (million $, present values)
Types of Benefits		
1. Fishing, swimming, recreation near water	1 million visits	10 to 30
2. Improved aesthetics for users--recreators and property owners near stream		
3. Improved aesthetics for nonusers--value to residents in area from knowing stream is clean should they use it or from just knowing it is clean		
4. Enhanced ecological diversity	10 new fish species, smallmouth bass and others; 1,000 acres of improved wildlife habitat; no unique species are provided	
Types of Costs		
1. Advanced treatment for municipal wastes	1 new plant	8 to 10
2. Advanced treatment for industrial dischargers	3 additional treatment operations	1 to 4

Table 2-3. Benefits and Costs of Attaining Fish and Wildlife Use: Array 3

		Quantity	Monetary value (million $, present values)
Types of Benefits			
1.	Fishing, swimming, recreation near water	1 million visits	10 to 30
2.	Improved aesthetics for users--recreators and property owners near stream		5
3.	Improved aesthetics for nonusers		2
4.	Enhanced ecological diversity	10 new fish species, although no unique species are provided; 1,000 acres of improved wildlife habitat.	Not monetized
Types of Costs			
1.	Advanced treatment for municipal wastes	1 new plant.	8 to 10
2.	Advanced treatment cost for industrial dischargers	3 additional treatment operations	1 to 4

costs. By monetizing these benefits with. a contingent valuation survey (discussed in Chapter 3), the practitioner can show that the minimum benefits exceed even the highest cost. This makes a strong case for adding the use. In addition, the array in Table 2-3 shows nonmonetized benefits that would increase the total value of the benefits even more. This example illustrates the case for a river segment with large recreation potential that justifies the extra cost involved in carrying out the detailed assessment. River segments that have intermittent flows or whose entire flow is effluent would have low recreation potential and would not require such a detailed assessment.

To show how the system of arrays can present assessment results, the discussion of this example concentrates on the efficiency aspects of the use designation. As noted in Section 2.4, however, the decision process also should consider information on distribution effects.

2.3 COST IMPACT MEASURES

This section describes the general approach and some specific measures for assessing the cost impacts on communities and industries of meeting water quality regulations. This handbook does not advocate the use of any one measure; rather, it emphasizes that impacts be evaluated. Overall, the objective is to determine the incremental effect of compliance costs on earnings, production, and employment in the affected locality. However, the financial ability of a community or industry to absorb these costs is also important.

For each major impact category, the following sections describe one or more measures with varying degrees of sophistication, data requirements, estimation methods, feasibility, and accuracy. By no means are these methods the only way to proceed.

Assessing Household Impacts

The share of publicly owned treatment works (POTW) costs allocated to households in the form of higher sewer or water charges is assumed to be borne directly by those households, reducing annual income by the amount of the total annual costs. This implies that households cannot pass on these costs by increasing their wages. Together with data on household income, total costs of compliance and community indebtedness are used to develop measures of the ability of households to bear these costs--i.e., how these costs affect income and indebtedness. The discussion of impact measures is kept brief here because an EPA document, the Financial Capability Guidebook,* provides a detailed guide to community financial capability analysis.

Household impact measures are divided into two major types: ability to pay and ability to finance. Ability-to-pay measures focus on the ability of the residents to bear the costs of water quality improvements, regardless of the current financial status of the community. Ability-to-finance measures focus on the ability of the community to finance the costs of compliance. The Financial Capability Guidebook develops 11 key indicators used to judge the ability to bear the impacts specified by these measures.

Ability to Pay

The measure of ability to pay is the ratio of compliance costs to median household income. Compliance costs are defined as total annual costs: the sum of annualized capital costs, operation and maintenance costs, and contributions to contingency funds. Focusing on values for the median household is convenient, but particular situations may call for a more detailed examination of the distribution of income or wealth in the community.

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*Municipal Finance Officers Association and Peat, Marwick, Mitchell & Co., Financial Capability Guidebook (Draft), prepared for EPA, Office of Water Program Operations, Washington, D.C., May 1982. Contact the OWPO at EPA for further information about this document.

The income measure may be used to estimate two kinds of cost impacts: the incremental costs of a particular water quality program and the total costs of compliance associated with all treatment. In some cases, total costs may be useful because the practitioner is interested in a view of cost impacts overall. For specific water programs, however, a focus on the incremental costs of decisions that move water quality beyond that resulting from the statutory, technology-based controls can reveal the cost impacts due to the individual program.

Financial Capability

The financial capability of a community has a significant effect on its ability to raise additional funds in the bond market. If a community has high indebtedness or low tax revenues, it will have a lower bond rating and face higher costs of capital. The impact measure is the total outstanding debt of the community before and after the project being considered.

Assessing Industrial Impacts

A firm's compliance cost may arise either from direct costs of treatment facilities or process changes or from its share of POTW costs. In turn, these costs lead to changes in profitability, output, and employment and may result in partial or complete closures. Of course, an accurate measure of impact requires some estimate of a business cash flow, but this estimate may be. difficult to obtain unless the companies concerned cooperate. Thus, a large tradeoff exists among the measures with respect to feasibility and accuracy. Table 2-4 summarizes the proposed impact measures, data sources, and their availability and reliability. The measures will be described in greater detail in Volume II.

Assessing Changes in Employment, Output, and Prices

Changes in output and employment in response to treatment costs are important because they give rise to indirect impacts. If workers are unemployed, they reduce their spending; if a plant reduces output, its demand for inputs from supplying firms slackens, with indirect repercussions on community income and employment. Even if estimating indirect impacts is infeasible, the direct effects of compliance costs on community employment and income are useful for assessing the equity implications of a regulatory action--"who is affected?"

As a rule of thumb for assessing the effect of regulatory actions, firms usually cannot pass through treatment costs by raising prices. This rule normally holds for water quality standard actions because they are site-specific and may affect only certain businesses. Although the rule may not hold for some regulatory actions, it is difficult to predict under what circumstances firms might be able to pass through costs.

Table 2-4. Summary of Industrial impact Measures

Measure	Source	Availability	Reliability
Profitability (including closure)			
1. Cost/sales ratio	Production and price estimates or public data bases	High	Low
2. Cost/production cost rat/o	EPA economic impact analysis	High	Low
3. Net cash flow	Plant financial data	Medium	Medium
4. Rate of return	Plant and company financial data	Low	High
5. Net present value	Plant and company financial data	Low	High
6. Company solvency	Company financial data	Depends on size	Depends on size
Reductions in employment and output			
1. Due to closure	Plant data	Medium	Medium
2. Due to output reduction	Plant data, engineering report	Medium	Medium
Price changes expected to be small			

2.4 WHAT TO DO ABOUT DISTRIBUTION: PROBLEMS IN ADDING UP OVER PEOPLE

Introduction

A net benefits estimate does not evaluate projects based on the distribution of net benefits. Rather, the evaluation is based on efficiency criteria,

which show how to allocate society's resources to maximize well-being.* Although the weights assigned to individual recipients of the benefits and costs of a project are treated equally, the distribution of net benefits can be described for the policy under evaluation. In these descriptions, benefits and costs are separated according to the economic agents affected. For example, one might classify households by income group, or firms by industry, and evaluate each group's share of the net benefits. Then, the overall benefit-cost assessment can account for distribution.

Some attempts have been made to explicitly include equity (in terms of the effects of the project on different income groups) in benefit-cost assessment. They are not uniformly accepted. All of the weighting schemes are based on the premise that the extra utility or satisfaction derived from an extra dollar of income declines as income increases. Thus, redistribution of income will lead to increases in total utility or satisfaction for society.

There are flaws inherent in any weighting scheme for benefit-cost assessment. The most difficult one to overcome is that it is hard to get society to agree on the appropriate weights. Equity in income is only one possibility; regional and racial equity are others. In the final analysis, the weights are simply attempts to "guesstimate" the decisionmaker's preferences. This does not imply that distribution information should not be developed. Rather, it suggests that the tradeoff between efficiency (as measured by the aggregate net benefits) and various types of equity considerations (as reflected in the distributions of these net benefits among economic agents under different classifications) is unlikely to be capable of being assigned a fixed relationship. Ultimately, the importance of distributional issues will depend on the decisionmaker's judgment.

Two examples can be used to illustrate how distributional information has supplemented the conventional net benefit information in a benefit-cost assessment.

Example I

Suppose an improvement in water quality will provide $10 million a year in net benefits. The distribution issue is to determine who will receive these benefits. The most commonly used method is to array the benefits by the shares that will accrue to different income groups, as shown below:

Income ($)	Percent of net benefits
Less than 10,000	20
10,000 to 20,000	30
20,000 to 35,000	35
More than 35,000	15

*Efficiency criteria indicate both the cheapest way of achieving a particular level of water quality and what level of water quality makes sense given competing uses of resources.

This change would favor lower income groups: half of the net benefits accrue to people with incomes of $20,000 or less, and over three-fourths accrue to people with incomes of less than $35,000 a year. By quantifying and monetizing benefits and costs, benefit-cost assessment provides a clear picture of the distribution effects of the change. The distribution of any intangible benefits and costs also should be considered in the decision.

Example II

Consider the same situation as in the previous example with $10 million in net benefits from the change in water quality. Table 2-5 arrays the distribution of benefits and of project costs. Rather than arraying by income groups, the categories in Table 2-5 break down the distribution of benefits and costs over broad groups in society to illustrate another way that distribution effects can be highlighted.

Table 2-5. Distribution of Benefits and Costs

Benefits: Who Receives?
• Users of river for recreation
• People who receive enhanced aesthetics values for river
• Downstream users for municipal water supplies
• Downstream companies who use water for industrial processes
Costs: Who Bears?
• Residents who incur higher sewer and water bills because of advanced treatment requirements for wastes
• Stockholders of companies who have to install new equipment or change production processes to meet the standards
• Consumers who purchase products whose prices are increased as a result of companies' compliance

Summary: Distribution

Information on distribution effects of water quality programs is an essential ingredient in a benefit-cost assessment. It can be described with either summary measures like income group shares, or simply listed in narrative form.

2.5 DISCOUNTING FUTURE BENEFITS AND COSTS: ADDING UP OVER TIME

One of the most crucial issues in a benefit-cost assessment that relies on monetized benefits and costs is the selection of the appropriate discount rate--an interest rate used to translate dollar amounts of benefits and costs occurring in different years into a common unit of comparison, usually a present value. The discount rate is a positive number because individuals prefer immediate consumption and the associated immediate satisfaction to future consumption and the corresponding future satisfaction. Then, to persuade individuals to give up immediate consumption in exchange for future consumption, the level of consumption must be increased at that later date. This increase is an opportunity cost and is demonstrated, for example, when companies pay interest, or share future profits, to take advantage of current investment opportunities. Preference for satisfaction now rather than later--technically known as the positive rate of time preference--is demonstrated when someone installs new carpet on a time payment plan or finances a new car. The satisfaction or utility from the carpet or car is gained now at the expense of a financing charge.

There are five key concepts in determining discount rates:

- Social rate of time preference: the rate at which society is willing to exchange present consumption for future consumption.

- Consumption rate of interest: the rate at which individuals are willing to exchange present consumption for future consumption.

- Marginal rate of return on private investment: the incremental return on the last unit of investment by a private firm.

- Opportunity cost of public investment: the cost of a government investment measured in terms of forgone private consumption or investment.

- Risk: the degree to which investment in a public project will affect the variation in the outcome of all public investment.

While a large share of the costs of meeting a water quality standard occurs in years immediately after a standard is set (e.g., firms invest in new treatment processes, and cities construct advance waste treatment plants), benefits will not accrue until after the new plants and processes are in place. These benefits may accrue for 50 or 100 years--a period over which dollar amounts of both benefits and costs will vary greatly. The pattern of discounted net benefits often will look very different if a high discount rate is used rather than a low one. As this example shows, assessing benefits and costs of any water quality program requires an appreciation of the basic principles underlying the definition and the selection of an appropriate discount rate, an understanding of the empirical implications of discounting, and a practical knowledge of how to work with discounting techniques.

Time Preference: What Is It?*

The use of discount rates in benefit-cost assessment can be explained by viewing discounting issues within the context of an ideal market economy, the characteristics of which include perfect competition in all markets, complete certainty in decisions, no transaction costs, no taxes, and no limitations on any credit market. In such an economy, all goods are priced at the opportunity costs of the inputs used to produce them, and individuals and businesses are able to borrow or lend, subject to their ability to repay; as much as they desire at the market rate of interest, which is determined by the demand and supply of loanable funds.

In hopes of obtaining future earnings, businesses in this ideal world would invest funds to the point where their extra benefit equals their opportunity cost. In this economy, the market interest rate will be the opportunity cost of capital for the firm. Consequently, optimizing behavior by each business and efficiently working markets will ensure that the market interest rate will be equal to the marginal return on investment. The firm could not rearrange its investments and improve its long-term profit picture. At the same time, individuals would arrange their consumption and savings such that their own marginal rate of time preference (also known as the consumption rate of interest) would equal the market rate of interest. In this ideal case, the final outcome is that market forces create an equilibrium in which an individual's consumption rate of interest and a firm's marginal return on investment are the same because both correspond to the market rate of interest. This equilibrium ensures an efficient allocation of resources over time. If these equalities were not maintained (for example, if the consumption rate of interest were less than the marginal return on investment), an individual could improve his welfare (by consuming less, saving, and earning a return that permitted greater consumption in the future).

Introducing public investments--such as those mandated by water quality programs--requires that the resources supporting them displace either private consumption or private investment. An efficient allocation of resources means that these investments earn a return at least equal to the marginal return on capital or the consumption rate of interest that would be required for these alternative uses (i.e., private investments or consumption). If it is also assumed that all individuals are alike with respect to factors determining their rates of time preference, society's overall rate of time preference should equal the market rate.

The implication for selecting a discount rate for the water quality programs in an ideal society is that either the social rate of time preference or the opportunity cost of capital would be appropriate because they are the same--i.e., both are equal to the market rate of interest. Unfortunately, when the assumptions of the ideal case are relaxed, the two rates diverge. These divergences explain why the selection of a discount rate for public sector investments has been such a difficult and often controversial issue.

*This section draws extensively on Lind et al. [1982].

How To Determine the Discount Rate in a Less Than Ideal World

The selection of a discount rate for a benefit-cost assessment of a water quality program must be accomplished in a world considerably different from that of the ideal economy. Some of the most important divergences from the ideal economy can be attributed to the following factors:

- The tax on corporate income, which drives a wedge between the private rate of return and the rate of time preference. A higher rate of return on private investment is required to offset the effects of income taxes, which cause the divergence between social and private rates.

- The dependence of future generations on decisions made by present generations. This dependence gives rise to a "public good"--the welfare of the future generations--that may not be included in the decisions of the private market.

- Private markets, which may be out of long-run equilibrium with an immediate discount rate different from the appropriate long-term rate.

- The determination of the appropriate private market rate, which is difficult because there are numerous capital markets, each with its own interest rate.

- Public investment dollars, which do not necessarily displace private investment dollars but may instead use tax revenues that displace current consumption in the private markets.

Attempts to reconcile these divergences have created a complex literature on the criteria for selecting an appropriate discount rate for public investments or regulatory evaluations under different circumstances. Lind [1982] has distilled this literature, concluding that the rationale for discount rate selection should be based on the full opportunity costs of capital.

Lind's approach does not ignore the potential divergence between society's social rate of time preference and the market rate of' interest. Rather, he suggests that the social rate of discount be set equal to the social rate of time preference and that the shadow price of capital be used to adjust for the full opportunity costs of capital. The shadow price of capital is defined as the present value of the future stream of consumption benefits associated with $1 of private investment discounted at the social rate of time preference.

A benefit-cost assessment to evaluate government investment decisions based on this approach considers the implications that investments have for consumption over time. The basic question to be answered is, "What does public investment displace?" To the extent public investment displaces private investment, that portion of the costs of the public project should be valued at the shadow price of capital. That is, the costs of this portion of the investment are valued in terms of the consumption forgone. When the

forgone consumption due to displaced investment is added to the balance of the costs (i.e., those displacing immediate consumption), all costs have been converted to their equivalent losses in private consumption. Similarly, benefits that lead to increased private investment should also be adjusted to reflect their potential to yield future consumption streams. The adjustment is to multiply that share of the private investment by the shadow price of capital. This procedure adjusts benefits and costs at each point in time and expresses them in terms of the equivalent amount of consumption that could be obtained.

Table 2-6 shows estimates of various parameters so that a practitioner could use this general procedure in a benefit-cost assessment. The estimated value for the marginal return on private investment in Table 2-6 is 10 percent. This approximation is based on judgment and the empirical relationship that the estimated average return, adjusted for inflation, is between 10 and 15 percent. More accurate measurements of the costs of capital are hindered by the inconsistency between accounting data and economic concepts, and by implicit adjustments both for risk in the returns to capital data and for firms' inconsistencies in following established procedures to make capital budgeting decisions.

Based on depreciable assets data for 1973, 1974, and 1975, the length of the typical private investment is estimated at 15 years, with a range of 10 to 20 years. Based on empirical work on consumption and savings, the marginal propensity to save is assumed to be 0.2.

Table 2-6. Summary of Final Description Factors Influencing Shadow Price of Capital

Shadow price of capital	Marginal propensity to save	Marginal return on private capital (%)	Social rate of time preference (%)	Length of typical private investment (years)
1.62 to 2.57[a]	0.2	10	2	10 to 20
1.9[b]	0 . 2	10 to 15	2 to 6	15

[a] This row is based on Lind's Table 4 comparing the shadow price of capital under a range of assumptions for the social rate of time preference, marginal return on private investment, and length of typical private investment.

[b] This row is based on Lind's discussion on pp. 101-102 of the unpublished manuscript. The returns on private capital are pre-tax returns. The shadow price of 1.9 is the central value associated with the variations in each of the parameters involved. The range of values was 1.65 to 2.15. The range of social rates of time preference are reported to indicate that they would be consistent with this shadow price.

In the procedure, the social rate of time preference is set equal to the consumption rate of interest for individuals. Unfortunately, there is no unique rate of interest in the real economy. But it is possible to gain some insight into individuals' rates of time preference from their savings and investment decisions. For example, the real after-tax average rate of return on treasury bills (a safe investment available to many people) over the period 1926 to 1978 was -0.5 percent for an individual in the 20-percent tax bracket, and the return on a mutual fund containing "average market" stocks totaled 4.6 percent. For individuals, the real rate of return must lie somewhere between the riskless treasury bill rate and the stock market equity returns.

Adjusting for the effects of unanticipated inflation shows that the marginal rate of time preference must be in the range of -2 and 5 percent, with the average close to 0. Regardless of the actual point estimate selected, it will be considerably different from the 10 percent real rate of discount recommended by the Office of Management and Budget (OMB) for public investment projects.*

The shadow price of capital can be calculated from the estimates of the other parameters following Lind's procedures. Specifically, Lind estimates that the most likely value is within the range between 1.65 and 2.15. This shadow price is then used as described above to convert the benefits and costs into consumption equivalents.

Including Risk in an Assessment of Discount Rates

So far the implications of uncertainty for determining the discount rate have been implicitly ignored. Since the levels of benefits and costs are uncertain, there should be adjustments for the probabilities that a particular level of each will occur. Depending on its source and nature, the uncertainty can either be addressed in the choice of a discount rate or be directly reflected in the measurement of benefits and costs. Alternatively, some combination can be attempted. Each of these alternatives will be considered in Volume II.

The main conclusion that can be drawn from the risk studies covered in Volume II is that the characteristics of the public investment project, together with the relation between the variability in the public investment and the variability in national income, are crucial factors in determining whether a riskless or risk-adjusted discount rate should be used in an assessment of public investments. The important relationship that must be explored is whether water quality program investments increase the variability in national income. For most of these applications, the effects of risk will be small, and a riskless rate can be used.

*It is difficult to interpret this rate as an estimate of the social rate of time preference. It may well be the equivalent to a recommendation that all projects be discounted at the marginal rate of return on private investment. Additional confusion is added by the Water Resources Council [1979] guidelines which tie the discount rate to an index. The current rate in this procedure is 7-7/8 percent.

What Are the Empirical Implications of the Discount Rate Issues?*

One of the reasons for the controversy concerning the use of discount rates is that the empirical implications of the discount rate can have a substantial influence on the outcome of the benefit-cost assessment. Fox and Herfindahl [1964] reevaluated Federal water projects, previously evaluated at a 2-5/8 percent discount rate, at new discount rates of 4, 6, and 8 percent. Nine percent of the projects that previously had benefits exceeding costs at 2-5/8 percent experienced the opposite result with a 4-percent discount rate; 64 percent experienced the opposite result at a 6-percent rate; and 80 percent experienced the opposite result at an 8-percent rate. The implications are quite clear: Most of the projects had costs exceeding benefits at the higher discount rate, and all had positive benefits at the low 2-5/8 percent rate.

Many water program regulations or projects will have benefits that will accrue 10, 20, 30, or even 100 years in the future and costs that could be substantial during initial periods. For example, suppose a water quality project requires a $1 million investment in 1982 and will provide $50 million in recreation benefits at the end of 50 years. The net present values at different discount rates would be as follows:

Discount rate	Net present value
5 percent	3,336,186
8 percent	6,606
12 percent	-826,990

As shown, the discount rate is crucial in determining the ultimate assessment of benefits and costs. This emphasizes the importance of the sensitivity analysis recommended in Chapter 5, which shows that in some cases there will be positive net benefits regardless of the discount rate, while in others the outcome of the assessment is very sensitive to the discount rate applied.

Another important empirical distinction in discounting is the difference between real and nominal rates of discount. The difference is the expected rate of inflation. Most benefit-cost analyses are conducted using constant dollar values for the benefits and costs. In these cases the real rate of discount should be used.

Benefit-cost assessments have employed real discount rates ranging from 0 to 4 percent, while the nominal rates have ranged from 8 to 16 percent. The higher end of the scale for nominal rates represents the influence of recent high levels of inflation and market interest rates. The difference between the real and nominal rates is quite substantial and indicates why it is important not to mix the two in a benefit-cost assessment. For example, compare the implications of a real discount rate of 2 percent and a nominal rate of 10 percent (inflation is expected to be approximately 8 percent). With the

*This discussion is adapted from Just, Hueth, and Schmitz [1982].

nominal rate used as the discount rate, society would be indifferent between $1 now and $13,780 in 100 years. However, if a real rate is employed, the difference would be $1 now versus $7.24 in 100 years. Thus, although it seems low, given the high interest the economy is currently experiencing, a real discount rate of 2 to 4 percent may make considerable sense in a benefit-cost assessment where the long-term perspective is essential.

The Simple Mechanics of Discounting

This section offers a brief review of the mechanics of discounting. The reader is urged to consult a finance text for present value tables and more detailed discussions on discounting.

The discounting problem in a benefit-cost assessment is how to translate benefits and costs occurring in different periods into a common basis for comparison. The most frequently used basis is present value, which is defined as the amount of money at the present time that some future amount is worth. Discounting is the process of computing the present value of a future stream of dollars.*

Consider a simple example that might arise in the assessment of a water quality standards program. Suppose a State is considering changing the presently unattained use designation for a river segment from "fish and wildlife propagation" to "limited warmwater fishery." In this case, there will be a loss in potential benefits, as well as cost savings from the forgone pollution control investment for cities or industries. The monetary values for the benefits and costs associated with this decision are as follows:

Year	Benefits forgone	Cost savings
1982	40,000	$100,000
1983	40,000	10,000
1984	40,000	10,000

The discounting problem is:

1. Select the appropriate discount rate.

2. Translate future benefits and costs into present values for comparison.

The discounting formula for this procedure is:

$$P.V. = \frac{1}{(1+i)^t},$$

*For simplicity, assume all dollars accrue at the end of each year so there is no need to account for differences within a year.

where

P.V. = the present value factor for either benefits or costs

i = the discount rate

t = the time period.

The discount factor P. V. is multiplied by the benefits or costs for each period in the planning horizon; then the results are summed. Suppose that i = 4 percent with the monetary values for benefits and costs from above. The discounting calculations are the following:

$$\text{Benefits forgone} = 40{,}000 + \frac{40{,}000}{(1+0.04)^1} + \frac{40{,}000}{(1+0.04)^2}$$

$$\text{Cost savings} = 100{,}000 + \frac{10{,}000}{(1+0.04)^1} + \frac{10{,}000}{(1+0.04)^2}$$

	(1982) (t=0)	(1983) (t=1)	(1984) (t=2)	
Benefits forgone =	40,000 +	38,462 +	36,982 =	$115,444
Cost savings =	100,000 +	9,615 +	9,246 =	$118,861

Net cost savings = $3,317

The change of the use designation will yield a small positive cost savings. In this example, the forgone benefits end in 1984. In most cases, they would continue into the future for whatever time horizon is selected for the assessment.

If the benefit (or cost), stream is constant each year at A for the full life of the project (assumed to be n years), the formula for the present value can be rewritten as follows, often referred to as the present value of an annuity:

$$P = A\left(\frac{\frac{1}{1-(1+i)^n}}{i}\right)$$

where

P = present value

A = annual amount

i = discount rate.

Present value may also be determined by using the tables in a finance or accounting text. Another variation on the discounting mechanics is to trans-

late amounts into annual values that can be compared. The formula for this calculation, often referred to as the uniform-series capital recovery factor, is:

$$A = P\left(\frac{i(1+i)^n}{(1+i)^n-1}\right)$$

Discounting: A Summary Review

While the arguments summarized above require the use of judgment for each new situation, general guidelines do exist. For a wide range of water quality programs, the social rate of time preference would range from 2 percent to a maximum of 6 percent. The recommended procedure is to consider the implications of each of these values for the discounted net benefits of the decision.* If the present value of net benefits is positive and the project decision remains unchanged, it is unnecessary to further consider the technical issues affecting the selection of one value in this range. However, for those cases where the value of net benefits (i.e., positive versus negative) is affected by the discount rate, a more refined selection is recommended that considers the practical implications of Lind's analysis. This process requires answering four key questions:

1. What are the sources of the public investment resources? Are they tax revenues that can, in principle, displace private consumption or investment?† In addition, what are the likely portions coming from each source? Answers to these questions will affect the importance of estimating the shadow price of capital.

2. How large are the private investments required by the water quality action? If they are large, adjustment by the shadow price is likely to be warranted to reflect the full opportunity costs of these investments.

3. What is the nature of the risk associated with the investment and its relationship to overall economic activities? The answer to this question provides a basis for judging whether an adjument for risk should be made in evaluating the project. If most water quality investments increase the variability in economic activity for a State (or the county as a whole), then the selection will tend to be at the higher end of the range for the social rate of time preference.

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*In some cases, legal restrictions mandate the use of a specific rate; e.g., advanced treatment applications require the applicants to use the Water Resources Council's rate of 7-7/8 percent.

†User fees should be regarded as payments for services provided and therefore do not displace private investment.

4. Are the sources of finance for the project known in advance (i.e., Federal sharing of a local project's cost)? Since one objective of benefit-cost assessment is to improve the overall al location of resources, any Federal share of the costs should be treated in the same way as the local share, with consideration given to the full opportunity costs of the funds used.

It is impossible to recommend a single rate of discount as relevant for all situations; Each decision may well have special attributes that will need to be reflected in the selection. It is important not to let the technical considerations involved in defining the appropriate discount rate become overwhelming. For most purposes, the 2 to 6 percent range of values will be all that is necessary.

2.6 Summary

- intangibles should be viewed from society's willingness-to-pay benchmark even though they are incommensurable.
- Arrays or tabular displays are useful exposition tools for intangibles.
- Household impacts can be measured according to ability to pay or ability to finance.
- One measure of ability to pay is the ratio of compliance costs to median household income.
- Ability to finance is reflected in a city's bond market rating in the financial community.
- Industrial impacts can affect profits, output, and employment.
- Distribution can be highlighted in arrays showing who receives and who bears.
- Discount rates should be selected carefully. Shadow price of capital should be considered in gauging the full opportunity cost of public investment.
- A sensitivity analysis should be performed for the effects of selecting the discount rate. Several discount rates should be tried.
- The implications of risk should be considered for the discount rate. The relationship between the variability of investment or outcomes of regulatory policy relative to variability in national income should be considered.

- Net benefits should be determined on a present value basis. Formulae and tables should be used.

- Real and nominal discount rates should not be mixed.